# THE ARTIFICIAL PROPOGATION OF MARINE FOOD FISHES AND EDIBLE CRUSTACEANS.

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## II.—*The Artificial Propagation of Marine Food Fishes and Edible Crustaceans.*

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The art of pisciculture, in its modern restricted sense, commenced a century and a half ago with the discovery of an artificial method of fecundating and hatching the ova of fish. Fish culture of a simple elementary character, had been known and practised long before, indeed from a remote antiquity. This, however, does not appear to have gone further than the inclosing of fish in artificial aquariums, or in ponds where they were fed and tended till required for use. The art of acclimatization as regards fish, was understood to a limited extent. Favourite breeds of different kinds of fishes were fattened and flavoured in order to gratify the palates of epicures. The luxurious Romans spent enormous sums on their fish-ponds and oyster-beds. The ancient Egyptians are known to have reared fish in artificial inclosures on an extensive scale If we may believe what is told us of the Chinese, it would appear that for many centuries fish-culture of an ingenious kind has been carried on in China by collecting fructified fish eggs from lakes and rivers, carrying them to the interior, and selling them to proprietors of canals or ponds in which they are hatched and grow to maturity. The result is stated to be an abundant supply of fresh water food fishes in many portions of China.

With the discovery of the process of artificial fecundation of fish ova, pisciculture took a new departure, and by slow and painful steps has reached its present stage, which renders it an art of high national importance and gives promise of its becoming a potent factor in the future for securing sustenance for the teeming populations of the world.

As in the case of many other valuable discoveries, some doubt exists as to who is to be credited with the honour of this discovery. The French claim that Joseph Remy, a peasant of the Vosges, was the discoverer about the year 1842; and that with him originated that artificial system of fish-breeding which extended over their chief rivers, and at length culminated in the celebrated establishment of Huningue, near Bâle, for the collection, hatching and distribution of fish ova.

There can be little doubt that Remy's was an independent rediscovery, and that he carried it into a practical application which proved fruitful in results. He had been anticipated, however, by almost a century, by Ludwig Jacobi of Westphalia, in Germany, who, about the year 1748, carried out successful experiments in breeding salmon and trout. For eighty years he and his sons carried on the enterprise, on his own estate, as a commercial speculation, with great success. He also wrote an elaborate essay on the art of fish-culture which attracted the attention of many scientific men. His discovery was the result of keen observation. He found that the fecundation of salmon ova was an external act that could be readily imitated by careful manipulation, and that by this

method fish could be multiplied to an unlimited extent. To Jacobi then must be awarded the honour of first discovery.

There is little doubt too, that in 1837, John Shaw, of Drumlanrig, Scotland, a forester of the Duke of Buccleuch, independently rediscovered the process. He had undertaken to prove that parrs were the young of salmon, and conducted a long series of experiments with this view, in the course of which he fecundated and hatched the eggs of salmon. He did not, however, go farther than to establish scientifically the principle involved, while Jacobi and Remy turned it to practical economic account. Shaw's experiments, however, were completed and reported to the Royal Society of Scotland before Remy's discovery.

To France, however, must be accorded the honour of erecting at Huningue the first fish-breeding establishment in which the art was turned to practical economic account, and its usefulness to the general interests fully established. The advantages of the artificial method, in the rapid multiplication of fish, and in the preservation of the ova and young fry from the destruction inevitable in the natural process, became speedily apparent. The Government of France speedily took the new discovery under its fostering care, and immediate and substantial success followed. The rivers and lakes of France were soon extensively cultivated, and fish ponds of considerable extent were constructed. The system quickly spread over the whole continent of Europe, and everywhere aqui-culture began to yield highly profitable returns.

About 1850 the fine breeding establishment of Stormontfield, on the river Tay, near Perth, commenced operations and was conducted with admirable skill and marked success. In the same year Norway embarked in the enterprise under government patronage. Three years later (1853) the United States entered on the work, and developed it with characteristic energy and on a scale previously unknown. In 1863, Canada commenced public fish-culture, and can now boast of possessing a thoroughly organized system, skilfully conducted on scientific principles, fully abreast of the age and yielding most satisfactory results.

The evolution of fish-culture has thus been a very slow process. Though almost coeval with civilization in its inception, it made no marked progress till Jacobi's discovery, in 1748; and afterwards it required a century before it attracted the attention of the world and received any general acceptance. Even now it encounters much opposition, and in many civilized countries is still regarded with such doubt and distrust that it makes little progress. This, however, is the fate of all new ideas which have to do battle with apathy, ignorance and self-interests, and the innate indisposition of men to leave the beaten paths. As a rule, mankind know not their benefactors, and regard all innovators as disguised enemies or open destructionists.

At first fish-culture was generally carried on as a private enterprise for individual profit. Gradually, however, its importance was discerned, and its promotion and control were, in some countries, assumed by the State for the benefit of the whole community. If lakes and rivers which were open to the public, and in which no one could claim the right of property, were to be stocked artificially, the work must be done, not by private enterprise which was inadequate, but by governments, out of the public funds to which all contribute. Thus fish-culture on an extensive scale, with costly apparatus and a staff of officials and employees, became, in time, to be regarded as a function of the State.

Scientific men and skilled experts could alone conduct operations successfully; and as these were performing a work which was designed for the benefit of the community at large, it was felt to be right that the cost should be met out of the public funds.

National fish-culture has thus obtained a recognized place, and is steadily advancing in most civilized countries. Water-farming may, in the near future, under the guidance of science, approach the dignity and importance which are now attached to the cultivation of the soil. Food-factories will no longer be confined to the land, but, at the bidding of science, the waters will "bring forth abundantly the moving creature that hath life," and with fresh emphasis the ancient precept will be repeated, "cast thy bread" (or seed) "upon the waters, thou shalt find it after many days."

The first efforts of fish-culturists were limited to fresh water food fishes, such as trout, or to the anadromous species such as the salmon. By far the most extensive operations were conducted in the artificial breeding of salmon as being a money-yielding fish of great commercial value. Strikingly successful results were reached, both in Europe and America, in restocking exhausted rivers with salmon, in keeping up the supply where heavy drafts threatened scarcity or depletion, and even in establishing fisheries in waters where salmon were previously unknown. Of course, due protection was combined with artificial breeding. Judicious legislative enactments were adopted to regulate the times and modes of fishing and to secure the removal of obstructions to the ascent of the fish to their spawning grounds. The salmon rivers of Scotland, such as the Tay, where salmon-culture has been carried on for many years, present the most striking instances of the value of artificial breeding; while the Doohullah Lakes in Ireland furnish an example of the creation of a valuable fishery by placing artificially bred salmon fry in waters where no salmon had been previously seen.

Similar successful results have been reached in many of the rivers of continental Europe. Still more remarkable have been the results of fish-culture on this side of the Atlantic. Every state in the Great Republic has now its Fishery Commission and numerous hatcheries with qualified experts in charge; while in connection with the United States Fishery Commission—a national institution—a band of scientific men devote their energies to the investigation of fish-life in all its varieties, and a study of the physics of the sea. The work accomplished by this commission has called forth the admiration of the civilized world. The founder—the late Professor Baird—a man of the highest attainments as a naturalist—has been succeeded by Colonel Marshall Macdonald, whose great ability and matchless zeal are admitted on all hands. The Canadian Department of Fisheries has accomplished a work only second to that of the United States Commission; and in the intelligent organization and guardianship of the fisheries, and the practical improvements it has introduced, it has shown what science and practical skill can do in the guidance of these great national industries. Under the veteran fish-culturist, Mr. S. Wilmot—a man of European reputation—Canadian pisciculture now compares not unfavourably with that of any other country.

In the United States fish-culture has been for years carried on in salmon, shad, alewives, whitefish and carp. In Canada the artificial propagation of salmon and of the valuable whitefish in the great lakes, has been conducted on a large scale and with successful results. Both the United States and Canada contribute to the maintenance of the highly valuable whitefish fishery of the great lakes by planting each year in their

waters many millions of young fry. But for this artificial supply, the enormous drafts on this fish, by the fishermen of both countries, would long since have caused a decline which must ultimately lead to the extinction of an industry now employing thousands of men and a large fixed capital, and furnishing immense supplies of wholesome and agreeable food to an increasing population.

While the culture of fresh water fishes has thus been increasing in importance, a very striking advance in the art has been made in recent years, by extending its operations so as to embrace marine food fishes. It is needless to say that this enormously widens its field of operations and increases its prospects of usefulness to an unlimited extent. If the food fishes of the sea and edible crustaceans can be multiplied artificially, then we can imagine a time when the coastal waters will become great sea-farms, yielding enormous supplies of food for man, and even in the end approaching those of the land in value, and when salt and fresh waters everywhere will be cultivated with as much assiduity and skill as are now the continents and islands of the globe.

This is no mere flight of fancy. Keen-eyed science has taken the matter in hand, and is subjecting to her scrutiny the entire life-history of those finny tribes which can be made subservient to human necessities. Nothing escapes her observation. The minute eggs, transparent as crystal, and hardly discernible by the naked eye, which are cast into the waters in countless myriads, are patiently studied from the moment when the first movements of the mysterious principle of life begin, on through their phases of development till they reach the stage when they are able to "repeat the story of their birth." Science will not rest satisfied till the full biography of these nurslings of the sea is completed. Her investigations include not only their embryology, but their whole surroundings—their food, habits, migrations, their rate of growth, their friends and enemies, their birth and death-rates, as well as the physical condition of the waters in which they have their being. All the knowledge thus acquired is then to be applied practically, so as to guard them from injurious influences and destructive modes of capture; and above all, to the multiplication of their numbers and the restocking of exhausted waters, in cases where fisheries have ceased to be remunerative. Even the planting of maiden waters with new life-germs, and the improvement of breeds by crossing are within the scope of this new art.

Fish-culture has thus a wide range, and it is not unworthy the attention of the keenest scientific intellects. Its aim is noble—an extension of man's dominion over nature with a view to the increase of human resources and the food supplies of nations. As yet it is but in its infancy; but it gives promise of a vigorous growth. What it has achieved is a pledge of what it is destined to accomplish. Of course it has its limitations, just as farming and stock-raising; and there are many difficulties and obstacles yet to be overcome. Now, however, that it has given proof that it can deal successfully with the great sea fisheries—such as those of the cod, herring, mackerel, haddock, as well as with the anadromous fishes and the more valuable crustaceans, it is difficult to set bounds to its possible achievements. Certainly no other art gives promise of such beneficial results, of a practical character, as fish-culture.

The honour of carrying fish-culture into this new domain must be awarded to the late Professor Baird, though experiments with the same object in view were commenced about the same time at Flodevig, Norway, as in the United States. Professor

Baird, however, led the way on this side the Atlantic; and he and his colleagues, after a long and patient struggle with obstacles and difficulties, won a brilliant victory, and demonstrated to the world that the food fishes of the sea were as amenable to control as the anadromous and fresh water fishes, and could be artificially multiplied to an indefinite extent. A vastly greater field of usefulness was thus thrown open to fish-culturists. Not only so, but Professor Baird was able to formulate the great law of fish-life on which the new departure rested, and thus to remove it from the region of empiricism, and give it a solid scientific foundation. This great law he stated in the following terms: "In regard to the sea fisheries, one important principle should be carefully borne in mind, and that is that every fish that spawns on or near the shores has a definite relationship to a particular area of sea-bottom; or in other words, that as far as we can judge from experiment and observation, every fish returns, as nearly as possible, to its own birth-place to exercise the function of reproduction, and continues to do so, year after year, during the whole period of its existence. A second law equally positive, with a great variety of fish, is, that they pass from their spawning grounds to the sea by the shortest route that will take them out into the deeper waters where they spend the winter, and that coming and going to and from a given locality, they follow a determinate and definite line of migration."

Having established this important law by a long series of careful observations, Professor Baird deducted from it the following corollary: "The supply of fish in a given bay, or along a certain stretch of the coast, may be reduced to a considerable degree, and although it may be perfectly true that the sea is practically inexhaustible of its fish, yet when the fish of a particular region are cleaned out, there is no hope that others will come in from the surrounding localities to their places, since those already related to a given undisturbed area continue in that relationship, and have no inducement to change their ground. It should therefore be understood that the exhaustion of a local fishery is not like dipping water out of a bucket, where the vacancy is immediately filled from the surrounding body, but is more like taking lard out of a keg where there is space left that does not become occupied by anything else."

The latest and most advanced investigators of the biology of the sea strongly confirm Professor Baird's views, and establish the law which he expressed in the foregoing terms. More and more it becomes evident that the migrations of fish which spawn near the shore are of a limited character, being mainly from deep to shallow water and *vice versa;* that they are *local*, in the sense of "having a definite relationship to a particular area of sea-bottom," and that they return to the waters in which they had birth, and in which their early days were spent, to perform the most important function of their existence. The objection, therefore, so frequently raised, that it is useless to attempt stocking artificially an area of sea, whether in bays or coastal fishing-grounds, as the young fry will disappear in the wide ocean, falls to the ground. The notion that these fishes are wild ocean-rangers, constantly engaged in extensive migratory journeys, must be discarded. No doubt there are pelagic fish which spawn in the open sea, far from shore; but all, or nearly all our valuable food fishes are local. Hence, by artificial means, we can multiply their numbers in any given locality suited to their existence.

Another mistaken view must also be got rid of, namely, that exhausted fishing grounds have only to be allowed to remain unfished for a time and they will recuperate

without any aid from man, by fresh arrivals from other localities. Experience has shown that fish in surrounding localities will not change their ground to fill up vacancies; but in obedience to the law of their existence, will continue in their own habitat. Without artificial propagation therefore, when exhaustion is extreme, restoration is impossible; and even in cases where depletion is but partial, a long term of years is needed to secure improvement, which may be greatly shortened by artificial means. Besides, the question presents itself, what is to become of the fishermen while the fishing-grounds lie fallow? Scientific fish-culture presents the remedy by planting millions of young fry in the depleted waters, which in a brief period, will restore the exhausted fisheries. This process can be continued, year after year; and even heavy drafts will fail to bring exhaustion, when the stock is in this way constantly replenished.

These are not mere unsupported theories. They have been amply sustained by the results which have attended the artificial hatching of codfish in the United States and Norway. The cod is the grand staple of marine industries on this side of the Atlantic. Many thousands of men and a vast amount of capital are employed in the cod-fisheries of North America, the annual returns being not less than twenty or thirty millions of dollars. During many years past this industry has shown serious symptoms of decline, especially on the coasts of New England. In many localities where cod were once abundant, they are now scarce or have altogether disappeared. Even the great cod-fisheries, such as those around the shores of Newfoundland, and at Lofoden in Norway, have, in recent years, presented signs of decline which must be regarded with feelings of apprehension in looking to the future. In view of these facts, the question, can science provide a remedy? presents itself with fresh emphasis.

In 1878, Professor Baird entered on a lengthened series of experiments designed to determine the practicability of the artificial propagation of cod on a large scale. In one of his earliest reports he remarked: "Whatever may be the importance of increasing the supply of salmon, it is trifling compared with the restoration of our exhausted cod fisheries; and should these be brought back to their original condition, we shall find within a short time an increase of wealth on our shores, the amount of which it would be difficult to calculate."

Great difficulties were encountered in hatching the cod ova, but they were overcome; and after the experimental stage had been passed, Professor Baird was able to report that the feasibility of the artificial propagation of the cod family was fully established. "It is now" he said, "believed to be possible, not only to greatly increase the supply of the cod where it is at present found, but by carrying the young to new localities, to establish cod-fisheries so far south as the coast of North Carolina, where the fishermen may find regular occupation during the winter, now their poorest season in capturing these fish in large quantities, and supplying the adjacent markets, and even exporting them." At a later date he said, in reference to the artificial breeding of marine food fishes: "We have at our command the means of so improving and increasing the American fisheries as to obviate the necessity, in the future, of asking a participation in the inshore fisheries of the British provinces, and thus of enabling us to dispense with fishery treaties or fishery relations of any kind with the British or other governments."

The progress of the artificial breeding of marine food fishes since these words were written, proves that Professor Baird was not over-sanguine when thus prognosticating the

future. The success of the Gloucester, Wood's Hall, and Ten Pound Island hatcheries, is now a matter of history. Many millions of codfish have been hatched and "planted," and the benefit is already felt in the fishing grounds off Cape Ann, and at Nantucket Shoals, where we are told, on the best authority, "millions of these species, of one and two years' growth, are reported as being on the fishing grounds near the coast, while young cod have been taken in traps and otherwise, where the oldest fishermen have no recollection of seeing them before. The restocking of the shore grounds is proving a bonanza to the local fishermen, their catches being greatly increased." The shad fishery from Connecticut to North Carolina is reported to have increased twenty-five per cent in five years, in consequence of artificial propagation.

Not less remarkable has been the success of cod-hatching in Norway, where it was carried on in the Flodevig hatchery simultaneously with the work in the United States, and with equal skill and perseverance. In the spring of 1891, 620 litres of cod-spawn were dealt with, representing 279,000,000 eggs. At a part of the Norwegian coast between Sornskill and Hambo, 166,500,000 cod-fry were planted, in addition to 26,000,000 in other places. From 1884 till 1890, there were hatched in all 140,000,000 ova. As a consequence of these satisfactory results, the hatchery at Flodevig has been doubled in size, and a large pond has been constructed in which the cod are placed and allowed to spawn in the natural way, instead of undergoing the "stripping" process as formerly. The eggs when fertilized by contact with the milt in the pond, are skimmed off and placed in the hatching boxes. By this improved method, there is a gain of from twenty to forty per cent in the number of eggs hatched, the injury to the ova through handling the fish being avoided.

The confidence of the Norwegians in this method of increasing their sea-fisheries may be judged from the fact that this year (1892) they are engaged in the erection of another cod-hatchery at Dobak, sixteen miles from Christiania, sufficiently large to turn out four hundred millions of cod-fry annually. This is done with the view of restocking the Christiania Fiord, where there has been a great falling off of late in their number; and the supply of fresh cod to the markets of the capital and other towns on the Fiord, has been getting shorter every year, and the prices for codfish exceedingly high. In connection with this hatchery there will be erected a Biological station, where students from the University of Christiania will have an opportunity of studying, and of obtaining a practical and scientific knowledge of Ichthyology and Marine Biology, in all their branches, and where fresh specimens of marine fauna will be constantly on hand. This is not all. Another hatchery, with a fishing school attached, is in course of erection at Bodo, and will be in full operation in 1893. As Bodo is only a short distance (ten miles) from the Lofoden Islands, where the greatest of the Norwegian cod-fisheries is carried on in winter and early spring, it will be an easy matter to furnish the hatchery at Bodo with spawn from Lofoden, as all the fish caught there are spawning fish.

When we compare the work done in the United States, Canada and Norway, in connection with fish-culture and the improvement of the fisheries, with similar work in Great Britain, the contrast is surprising. In all matters relating to fish and fisheries, Britain is far behind the countries named. At one of the Fishery Conferences, during the London Exhibition of 1883, Professor Huxley remarked that "if they were going to deal seriously with the sea-fisheries" (of England) "and not let them take care of themselves, as they had done for the last thousand years or so, they had a very considerable job before

them; and unless they put into their organization of fisheries, the energy, the ingenuity, the scientific knowledge and the practical skill which characterized Professor Baird and his assistants, their efforts were not likely to come to very much good." At the same conference, Mr. S. Wilmot, of the Canadian Department of Fisheries, expressed his surprise that "in a vast and intelligent country like Great Britain, the Government had not taken up this question of protecting, improving and advancing the interests of the fisheries." He was of opinion that this was a work rather for the State than for private persons, and he was supported in this view by Professor Brown Goode, the Director of the United States Exhibit.

It is no doubt true that in England, for years past, successive Fisheries Commissions have been appointed; but these have devoted their energies to taking the evidence of fishermen and others engaged in the fisheries, and embodying it in voluminous reports, from which nothing of a practical nature came. Professor Huxley, who took part in this work, in his inaugural address at the London Exhibition of 1883, expressed the astonishment he felt on discovering that fishermen know nothing about fish except the way to catch them. "In answer to questions," he remarked, "relating to the habits, the food and the propagation of fishes—points of fundamental importance in any attempt to regulate fisheries rationally—I usually met with vague and often absurd guesses in the place of positive knowledge."

Very different has been the method adopted in Norway, the United States and Canada. In Norway, instead of appointing a commission to take the evidence of fishermen, a body composed of four distinguished men of science was appointed to investigate the biology and physics of the sea; and on their reports was founded that organization of the fisheries which has led to such important results, and those experiments in the culture of marine food fishes which are yielding such abundant fruits. One brilliant outcome of this commission which has been carrying on its operations for more than twenty years, was Professor Sars's great discovery that the eggs of the cod, the haddock, the gurnard, and most food fishes with the exception of the herring, instead of resting on the bottom, as had been previously universally believed, floated, in almost invisible globules, at or near the surface of the sea. This discovery laid the foundation of the scientific culture of marine food fishes.

In the United States, the same method was followed. A distinguished naturalist—Professor Baird—was, in 1871, placed at the head of a commission who wasted no time in taking the evidence of fishermen, but set to work on an investigation of the causes which had brought about a diminution of the commercial fishes and of the remedies adapted to remedy the evil. The result has been a thoroughly equipped department, with a large staff of scientific and skilled men, having the means of carrying on hatching operations on a large scale, both in fresh and salt water fish, and for studying the whole natural history of the various fishes. The splendid reports of this commission, issued annually since its commencement, are of inestimable value. Up till 1883, Congress and the various State Governments had appropriated over two and a quarter millions of dollars for the work of the Fishery Commission. Since that date there has been no diminution in the liberality with which the work has been sustained.

It would seem that at length Great Britain has been roused to the necessity of regulating and improving its fisheries on the same scientific lines as other countries. The

inauguration of a Fishery Board for Scotland a few years ago, marked the commencement of a new era. Under such eminent naturalists as Dr. Wemyss Fulton, Secretary for scientific investigations, Professor McIntosh, LL.D., Mr. J. H. Fullerton and D. J. Beard, excellent work is done in the investigations of the life-history of the various food fishes, from which important results will follow. The Annual Reports of the Scottish Fisheries Board contain matter of profound interest to the scientific fish-culturist.

Last year, this Board decided on adopting the artificial breeding of valuable sea-fishes with a view to the improvement of the Scottish fisheries. They had been for some time closely observing the work carried on at Flodevig, Norway, in cod-hatching, and had received official reports from time to time. The issue was a resolution to take up the same enterprise. By an arrangement with Mr. Dannevig, manager of the Flodevig hatchery, a wooden building with a complete hatching apparatus, was constructed at Arendal, Norway, and has recently been shipped to Scotland, where it will be in operation before the end of the present year. The Governments of France, Russia, Italy and Belgium, have been in communication with Mr. Dannevig, with the view of procuring from him plans and directions for fitting up and working similar establishments; and it is possible that these countries will shortly have marine hatcheries in active operation.

England is at last moving in the same direction. At a conference held in the Fishmongers' Hall, London, in March last, the following resolution was unanimously adopted: "That this conference, in view of the diminution of food fishes, is of opinion that sea-fish hatcheries should be established, as in Norway, the United States, Canada and Newfoundland, for the purpose of increasing the fish supply; and that it is of the greatest importance to the fishing industry that marine laboratories should be established at suitable points round the coast of the United Kingdom, with a view of affording information to practical fishermen and others, regarding the habits and life-history of food fishes." At Liverpool a marine laboratory has been established, and another at Plymouth. Sir Edward Clarke, M.P., said, at this conference, that the Plymouth Institution had shown that fish could be hatched in large numbers; and he thought that the Government would be doing a great public service if it assisted in establishing hatcheries, so as to produce results similar to those produced in America.

In France, M. Gobin, Minister of Fisheries, has recently expressed strong opinions as to the diminution of fish around the shores, brought about chiefly by the increase of populations, the larger and better equipped boats and the application of steam and trawls. He looks upon the artificial hatching of sea-fish as the best remedy, combined with the protection of areas as nurseries. The State alone, he thinks, can undertake such work, and he urges the establishment of hatcheries in which the propagation of sea-fish can be systematically carried on upon an extensive scale. Physical research, respecting marine and inland waters, is now extensively carried out in France, with a view to its practical application in the increase of fish by culture.

It is thus evident that the culture of sea-fish is established on a solid scientific foundation. The day is gone by for assailing it as insanity, and its advocates as wild, speculative enthusiasts. In all civilized countries having an interest in fisheries, scientific investigations are in progress; and the improvement, regulation and extension of these great industries are becoming more and more objects of national importance. England's colonies, one after another, are entering on the work.

Newfoundland, Britain's oldest colony, has been tardy in entering on the work of organizing and regulating its fisheries and employing artificial propagation for their improvement. This work, however, was at length commenced three years ago, by the appointment of a Fisheries Commission, who have already achieved a very gratifying measure of success, and are engaged in organizing a system which, in the future, cannot fail to secure beneficial results. Indeed, the work of the Newfoundland Fisheries Commission, as described in their annual reports, has already attracted attention on both sides of the Atlantic, and won the commendation of some of the foremost men who are engaged in similar work elsewhere. In one branch—the artificial propagation of lobsters—Newfoundland is ahead of all other countries. The method introduced by Mr. Adolph Nielsen—the able Superintendent of Fisheries—is likely to be adopted generally wherever it is found practicable. Cod-hatching too, though only two seasons in active operation, has made good progress, and gives promise of valuable results in restocking the partially exhausted bays and fishing grounds around the coast. It may also be mentioned that a pamphlet on "The cure of codfish and herrings," drawn up by Mr. Nielsen and published by the commission, has been reprinted by permission by the Fisheries Department of Ireland, and widely circulated among Irish fishermen. The same work has been translated into French and circulated at St. Pierre and elsewhere.

Previously to the organization of a Fisheries Commission in Newfoundland, the fisheries had been left to take care of themselves. Naturally, these fisheries rank among the finest in the world; but reckless and destructive modes of fishing pursued by successive generations; the want of intelligent guardianship and legal protection; the absence of any definite knowledge of the fish and fisheries, based on scientific observations; and the utter neglect of any means of organizing and directing these great industries, at length resulted in an alarming decline of the cod-fishery, especially in the great bays and inshore fishing grounds, and a marked deterioration of the herring, salmon and lobster fisheries.

The present writer may mention, without egotism, that he took an active part, year after year, in pressing these matters on public attention, and urging the necessity of appointing a Fisheries Commission, under whose care the fisheries might be placed. The appointment took place in 1888, and he has acted as secretary up to the present time. Fortunately the services of an able Superintendent of Fisheries were secured in the person of Mr. Adolph Nielsen, formerly an inspector of Norwegian fisheries, a man of high character, and possessing a thorough scientific and practical acquaintance with all departments of fisheries. A brief account of the work done by this commission in the artificial propagation of codfish and lobsters may prove interesting as a further illustration of the topic under consideration.

As the outset, it may be well to notice an objection to the culture of sea-fishes which is often repeated. It is alleged that the most valuable of the sea-fish—such as the cod—are so prolific that even the most destructive operations of man can make little or no impression on their numbers. The female cod, for example, according to size, yields from two to nine millions of eggs each season. The salmon deposits a thousand eggs for every pound of its live weight. The sole gives a million of ova annually; the flounder a million and a quarter; the mackerel half a million; the herring thirty-five thousand; the turbot fourteen millions, and a conger eel 28 lbs. in weight yields fifteen millions of eggs each season. The crustaceans are hardly less prolific than the finny tribes. An oyster gives

birth annually to a number of eggs varying from half a million to a million. The female lobster yields from twelve thousand to twenty-five thousand ova each season. Crabs, periwinkles, mussels, have an amazing fecundity. Such being the case, it appears at first sight an absurdity to attempt to add, by artificial arrangements, to the population of the sea, when the natural rate of increase is so prodigious.

There is, however, another side to be heard from. The more extended the studies of naturalists regarding fish-life, the more apparent does it become that the waste and destruction constantly going on in the sea, of life in all its stages, from the spawn to the full-grown fish, is enormous. If nature produces with reckless prodigality, her destructive processes are on a corresponding scale. If there is no economy observed in the arrangements for the maintenance of life in the sea, neither are there bounds set to the destroying agencies. A silent war is ever raging in the ocean, and the slaughter is beyond all calculation. One race preys on another; and life can only be sustained by the destruction of some other form of life. In the great world of waters, with its shallows and its depths, its vast plains, its hills and mountain ranges, how marvellous the diversities of life! But there death and terror are ever raging, under the most placid surface. The inhabitants live

> "A cold, sweet silver life, wrapped in round waves,
> Quickened with touches of transporting fear."

The work of destruction ever goes on, not only through animated forms, but by the physical forces of nature. Birth and death follow each other in mysterious rhythm, even in the profoundest ocean depths:—

> "Creator and destroyer, mighty Sea!
> That in thy still and solitary deep
> Dost at all being's base thy vigil keep,
> And nurturest serene and potently
> The slumbering roots of vast Creation's tree.
> The teeming swarms of life that swim and creep,
> But half aroused from the primordial sleep,
> All draw their evanescent breath from thee.
> The rock thou buildest and the fleeting cloud;
> Thy billows in eternal circuit rise
> Through nature's veins, with gentle might endowed,
> Throbbing in beast and flower in sweet disguise;
> In sounding currents roaming o'er the earth,
> They speed the ultimate pulse of death and birth."

Let us take the eggs of the codfish as an illustration. These are thrown from the mother-fish into the sea by thousands of millions. They float on or near the surface in the form of minute transparent globes, exceedingly delicate and buoyant. They dance about in the upper waters, and are driven far and wide by winds and currents. Their tendency is ever towards the surface, so as to reach the vivifying influence of heat and light. What becomes of these enormous multitudes of delicate egg-globes, hardly perceptible to the naked eye? Vast numbers of them fail to come into contact with the milt of the male which is also thrown into the same waters, the act of impregnation being external. The eggs quickly perish unless they are touched by the vivifying male element. They require from three to five weeks to hatch after being fecundated. All this time they are floating

near the surface, and countless myriads of them are thrown ashore by winds and currents, or carried out to sea where the conditions are far less favourable for either eggs or young fry, than in sheltered areas inshore. Meantime, fishes and sea-birds are devouring the eggs by millions, for to these enemies they are delicious morsels. When the young burst from the eggs, their movements are impeded for the first ten days by the yolk-sack which they carry; so that they cannot escape from their enemies, and the mortality among these handicapped water-babies is inconceivable. Surrounded as they are by hungry foes, "the slaughter of the innocents" goes on incessantly.

The consequence is that notwithstanding the fecundity of the cod, its actual yield of mature fish is small. Only a small number of all that are cast into the sea survive to become full-grown codfish. It has been estimated by competent judges, that out of a million eggs only one mature cod will be produced.

It is not surprising then to find that when to this natural waste, man's destructive enginery is added, and vast numbers of the young are captured before they have reached the period of reproduction, as well as of the parent fish, even an abundant cod-fishery may begin to decline, and finally be ruined. This has actually occurred on the coasts of New England, and in many other countries. Man's destructive agencies turn nature's delicate balance, and decline and extinction follow.

Now here it is where the artificial process shows its value. Every sound egg taken from the fish in the hatcheries, is fertilized by bringing it into contact with the milt, and from fifty to eighty or ninety per cent of the ova are hatched. The young are cared for and protected in their early feeble stage, and placed in the waters when able to take care of themselves; and thus their chances of survival are immensly increased. The cod being a local fish, the stock can thus be increased in any given area, and exhausted waters can be restored to former abundance.

If we take the herring, the mackerel, or the various species of flat fishes, we find the destruction of life among these is not less than among the cod tribes. The survival of one life-germ, out of a quarter or half a million of those produced, so that it reaches the stage of maturity, is found to be the average in many species of the more prolific fish. If this were not the case, the waters of the ocean would have been long since over-populated, and life rendered impossible. Even in the case of the salmon, "the monarch of the brook," it has been computed by a high authority that the yearly yield of the largest salmon-producing river in the United Kingdom is about equal to the produce of one female fish, of from 15 lbs. to 20 lbs. in weight, the produce of all the rest being lost or wasted. Sometimes an ill-timed freshet will destroy many millions of eggs, by tearing them from the gravel and laying them bare to a whole host of enemies.

It becomes apparent therefore that the argument against the artificial propagation of the valuable sea-fishes, on the ground of their superabundant fecundity, has no substantial foundation.

The cod-fisheries of Newfoundland furnish a striking illustration of the foregoing views in regard to the possibility of exhausting waters in which the fish-life was once superabundant. For three centuries and a half, the famous banks and the waters around the shores of the Island have been fished, mainly, but by no means exclusively, for cod. In regard to the Great Banks, those best qualified to judge are of opinion that the supply of codfish there is far from being so abundant as formerly, and that the decline, though

slow, is steadily going on, even in this wonderful "Home of the codfish." However this may be, there is no room for doubt as to the falling off of the cod-fishery around the shores of the Island. The most convincing proof is the fact that though the population has doubled within fifty years, and the number of persons engaged in fishing has greatly increased, while the various contrivances for taking fish have been multiplied and rendered far more efficient, yet the quantity of codfish taken annually at present does not exceed that of forty or fifty years ago, when the primitive hook-and-line was the chief instrument of the fisherman. This decline holds good, especially in regard to the great bays, around whose shores a large population has gathered. There was a time when a fisherman could fill his boat in a few hours with fine cod within sight of his own door. Now the fish are so scarce that large numbers of the fishermen are compelled to resort to Labrador and other distant fishing grounds, at a great increase of toil and expense, the waters of their own bays being largely depleted. Conception Bay was formerly one of the best fishing localities, and the population there became dense. Very little fish comparatively is now taken in its waters, and there are no signs, from year to year, of any recuperation. Placentia, Trinity, Bonavista, Notre Dame Bays, and other fishing centres have also suffered, more or less, in the same way. The size of the fish too has diminished,—a sure sign of a declining fishery. Reckless, destructive methods of fishing, as well as over-fishing and the extensive capture of immature fish, have combined in doing the mischief. No restraints were placed by law on the fishermen; and cupidity did not stop to consider the consequences in the future. Advancing depletion now threatens the shore fishery.

Such was the condition of affairs with which the Fisheries Commission, on their appointment, had to grapple. As a first step, they decided on the erection of a cod-hatchery, with the view of testing the practicability of restoring exhausted waters by artificial means. They considered that in those deep sheltered bays, with their arms running far inland, and the water possessing peculiar purity and salinity, they had very favourable conditions for hatching and rearing young cod. Dildo Island in Trinity Bay was selected as a site for the hatchery. The erection was on a large scale, and fitted up with all the recent improvements. It has capacity for hatching from two hundred and fifty to three hundred millions of cod-fry annually. If successful in Trinity Bay, cod-hatching could be gradually extended around the Island, and its bays and fiords, with the inshore fishing grounds converted into great codfish preserves. It was also decided that the artificial propagation of lobsters should be carried on simultaneously with that of cod-fish. In Newfoundland, as in every other country in which lobsters are taken, the fishery shows alarming symptoms of rapid decline which, if not arrested, must ere long end in the extermination of this valuable crustacean. Mr. Nielsen's invaluable invention of floating incubators for hatching lobsters rendered it practicable to carry on this process on a very large scale, and at many different places around the Island.

These hatching operations have been carried on during the summers of 1890 and 1891. One of the principal difficulties encountered has been the procuring of a sufficient number of ripe spawning fish to supply the hatchery with cod ova. The codfish around the eastern and northern shores of the Island spawn from the beginning of May till the end of July. The female codfish does not, like the salmon, accomplish the act of spawning at once. The eggs ripen gradually, and pass from the fish into the water as they mature, the period extending over six weeks. The spawners are kept in tanks in the hatchery,

and at intervals are taken out and "stripped"; then returned to the tank. The milt of the male is poured over the eggs which are placed in a proper receptacle with a small quantity of water, and the fecundated ova are then placed in the hatchery jars in which, by an ingenious contrivance, the water pumped into a cistern from a depth of thirty feet, is constantly kept in gentle motion, the eggs floating near the surface. In a temperature of 40° Fahr. the embryo cod hatches, or breaks through the egg, in twenty or twenty-one days. A lower temperature will prolong the period of development and one which is higher will hasten it. When the young cod escapes from the enveloping membrane, the mouth, tongue and digestive organs are not fully developed; but the young fish is provided with a yolk-sack containing nutriment on which it subsists for ten or twelve days. The mouth and digestive organs are now fully formed so that the young fry can seek food for themselves and are liberated in the sea. From fifty to sixty per cent of the eggs treated in the hatchery are hatched. By the construction of a pond in which the fish will be allowed to spawn in the natural way, Mr. Nielsen expects to hatch from seventy to ninety per cent of the ova, so that his output for the season will be greatly increased.

The first season for hatching (1890) proved to be very unfavourable, owing to the presence of unusual quantities of ice around the coast, in consequence of which the cod were late in approaching the shores. Seventeen millions of cod were hatched and "planted" in the waters. During the second season forty millions were hatched successfully. A much larger output is anticipated in 1892. The fishermen reported in 1891 seeing immense numbers of young cod in the waters where formerly none were found. That these were the products of the hatchery can hardly be doubted. Two years more will be required to determine whether the grand object aimed at can be fully attained, as a codfish requires four years to reach maturity.

Lobster hatching is a totally different process. The eggs of the lobster are fecundated within the body of the female, and when extruded are fastened to the fibrils under the tail by a glutinous substance. She carries them with her till they are hatched. At the lobster factories, arrangements are made for collecting these eggs from the captured lobsters, placing them in floating incubators in which they are hatched and afterwards set free in the sea. During 1890, the immense number of 406,005,300 young lobsters were hatched and planted in the waters. In 1891, the number hatched was 551,469,880. It should be noted that but for this artificial process all these life-germs would have perished, as the lobsters are boiled before being packed. The effect of preserving and bringing them to life cannot fail to have a most beneficial effect in sustaining the stock of lobsters and averting the deterioration or destruction of a valuable fishery. The commission are satisfied that by combining it with a close season and a proper regulation of the openings in the lobster traps, so as to permit immature lobsters to escape, the future of the lobster fishery is assured. Canada is likely to adopt Mr. Nielsen's floating incubators, and in Scotland they are also introduced. Lieutenant Gordon, R.N., who is well acquainted with the lobster fishery, says in his report for 1890, in reference to the value of Mr. Nielsen's floating incubators:—"Suppose the case of a cannery putting up 2,000 cases of lobsters, or 96,000 lbs., these require, say, a million lobsters to put up, and my inquiries show that probably one in five are 'berried' lobsters—say 100,000. Now take one-half of this and say that 50,000 'berried' lobsters, each carrying about 20,000 exuded eggs were destroyed in putting up the 2,000 cases, we have no less than 1,000,000,000 ova

destroyed, and if this rule be applied to the 220,000 cases which constituted the product of the fishery for the year 1889, we have a number of 110,000,000,000 as the wanton destruction of ova which it is possible, by the use of this simple means (Mr. Nielsen's incubators) to save, or at any rate, in some small measure; for even a saving of one per cent of such a total, represents a number the magnitude of which figures fail to bring home to the mind."

The propagation of codfish and lobsters is but a part of the work of the Fisheries Commission in Newfoundland. They diffuse information regarding the cure of codfish, the cure and packing of herrings; and construct and enforce rules and regulations for all the fisheries designed to protect and improve them, while they aim at maintaining a careful guardianship over the salmon rivers. In the herring fishery they have already accomplished an improvement which will be of immense value to the colony.

The remainder of this paper may be usefully occupied with some remarks on the development of the ova of the codfish and lobster, derived from observations at the Dildo hatchery.

The great majority of our marine food fishes deposit their eggs near the surface of the sea. These eggs are extremely buoyant, transparent as crystal, and, while in a living and healthy condition, will not sink. On the loss of their vitality, however, they sink to the bottom. The specific gravity of the cod ova is delicately adjusted to the salinity of the water. If the sea water on the surface becomes mixed with fresh water, as will occur after continuous heavy rains, the ova sink down until they meet water of a suitable salinity and density. When the fresh water has evaporated they will rise and float on the surface, their constant tendency being upwards, so as to come under the genial influence of the solar light and heat. These delicate little eggs have first to mature in the ovary of the mother-fish, and when ripened in this receptacle, the capsules which encompass them burst, and the ova are discharged into the water, looking like small transparent bubbles to the naked eye, and behaving in the sea just as soap-bubbles do in the air, dancing freely about when the water is agitated. The ripened milt of the male fish, containing the spermatozoa which are necessary to the impregnation of the egg, is discharged into the same waters and must come into contact with the ova before they can develop into fishes. It is marvellous to look upon one of these little transparent embryos of the cod as it bursts from the egg, barely visible to the naked eye, and weighing only the fraction of a grain, and to think that from it will be developed the lordly codfish, weighing forty, fifty or even sixty pounds. This growth takes place in three or four years, in which time it becomes perhaps half a million times weightier than at birth. It surpasses even the marvellous growth of the salmon which Frank Buckland considered to be the most rapidly increasing of all animals. He tells us that a salmon three days old is two grains in weight, and when it comes to maturity it may weigh thirty pounds and will then have increased 115,200 times the weight it had at first. But the cod surpasses this, starting from an embryo which is a mere fraction of the young salmon's weight.

The ovaries of the codfish are very largely developed, filling nearly the whole of the abdominal cavity. A very large cod has been known to contain nine millions of eggs. But it must be taken into account that these eggs are small, exceedingly delicate, and exposed to greater dangers during the course of development than the ova of fish which carry a smaller number. The latter are larger—as in the salmon—hardier and better

protected. Hence it comes that, as a rule, the fish which carry a large number of ova are in reality less prolific than those which carry a much smaller number of eggs, as a much larger proportion of the latter survive to maturity. An enormous proportion of the cod ova perish from their extreme delicacy and minute size. For the same reason, the artificial hatching of cod ova is difficult, and requires very delicate manipulation.

When in the hatchery, the cod ova are to be fertilized artificially, the female is taken from the tank in which they are kept till ripened, and held over a vessel partially filled with pure sea-water, in such a position that the weight of the ovaries presses upon the canal. The ova then run freely into the water in the vessel, without any pressure on the stomach of the fish The male fish, having ripe milt, is then taken from the water and held over the vessel in a similar manner, till the required milt has mingled with the ova. The fish are put back into the well or tank as soon as "stripped," to await further ripening, the period over which the process goes on being five or six weeks. The water containing the ova and milt is then gently stirred and left standing until the spermatozoa have entered the microphyle, a minute opening in the membrane surrounding the eggs. Having entered the ova, the spermatozoa do not disappear into the yolk, but form from their head or nucleus, the male pronucleus which meets and fuses with the female pronucleus, as the germinal vesicle is termed. "Fertilization depends upon the conjugation of these two sexually differentiated nuclei." From this conjugation-nucleus, formed by the fusion of the male and female nuclei, the new being takes its origin. A single spermatozoon is capable of fertilizing an egg.

When thus fertilized the eggs are cleansed, measured, so as to ascertain their number, and placed in the hatching apparatus for further development. The quantity of water, ova and milt must be duly proportioned to each other, in order to secure the fecundation of the egg.

After fertilization, the first real development of the embryo commences by the process of segmentation. In an unimpregnated egg, the germinal layer which covers the yolk appears like a transparent substance containing numerous minute vesicles. When the process of impregnation first takes place the egg turns a dull colour, but speedily brightens again, and the numerous minute vesicles become larger but less numerous, because they become confluent and unite. One hour after impregnation the protoplasmic layer can be seen travelling in beaded streams towards the lower pole of the egg, where the germinal disk is forming. The first mysterious life-movements have begun. In water having a temperature of 40°, three hours are required before the germinal disk becomes defined, and the protoplast extending from it is seen to embrace the yolk.

About six hours after impregnation, the segmentation of the germinal disk can be seen, by the aid of a microscope, to have commenced; and the egg, which originally consisted of one cell, is divided into two cells, through the shortest or equatorial diameter. Segmentation advances gradually by the two first cells dividing themselves and forming four new ones. Each of these again divides into two, and thus a multitude of small cells come into existence. Twenty-four hours after impregnation, segmentation has advanced so far that the germinal disk is divided into fifteen cells, and the nucleus can be seen through the cells. In two days the process in the cleavage of the disk is still further advanced and about sixty new cells can be counted, forming four layers, one over the other. As the segmentation goes on the cells become by the fourth day more and more

numerous, and the disk rises and assumes a convex form on the side pointing towards the yolk. After segmentation is completed, the disk sinks down and assumes a concave form, and is then termed the segmentation cavity, or embryonic disk or sack.

On the seventh day, the first indication of the embryo is defined in a thickened rim of the blastoderm, on the right-hand portion of the embryonic disk. On the eighth day the neural plate becomes visible, appearing like a cord lying across the egg, when viewed from below, and the embryonic sack has become more elongated.

On the ninth day the head of the embryo is defined and appears like a thickening mass on the lower part of the ovum; and the cerebral, with indications of the optic vesicles, can also be seen forming at the sides of the head.

On the eleventh day the first segment of the muscular system has appeared on each side of the neural canal, and the dorsal cord (notochord) can be seen below it. On the twelfth day the optic vesicles are seen more defined, while the muscular system and the notochord are more distinct.

When the embryo is fourteen days old the rudiments of the heart, pectoral fold, auditory canal and intestines can be seen. The stellated pigment cells are now also making their appearance.

On the fifteenth day the heart appears like a spherical cavity surrounded with a wall of connected cells; the fore-brain is further developed, and the optic system more advanced. The primitive lateral fin-folds can now be observed. The embryo has grown considerably and is lying near the membrane of the egg in the shape of a half moon.

On the sixteenth day the tail of the embryo cod becomes free and is twisted over to one side; the vent is also defined.

On the eighteenth day the heart is so well developed that it is seen to pulsate regularly, and the eyes are beginning to receive their colour. The pigment cells are also increasing in number, and the tail is now so well developed that it begins to straighten and move.

In water having a temperature of 40 degrees Fahr. the embryo cod will hatch, or break through the egg, in twenty or twenty-one days after impregnation. It escapes by bursting its enveloping membrane with vigorous strokes of the tail. For a day or two previous, the imprisoned embryo has been showing by its constant movements that it was eager to enter on its new and freer life in the great world of waters. The tail is the weapon by which it effects its freedom and is usually pushed out first through the gaping opening. The body, with a yolk-sack hanging to its under side follows. The mouth and digestive organs are not yet formed; but the yolk-sack, which has been formed from the egg, and is large in proportion to the fish, contains deutoplasm, an albuminous substance, which furnishes its nutriment for the first ten or twelve days, until the mouth and digestive organs are developed and the young fish can seek food for itself.

The baby cod, thus liberated, at once makes attempts to swim; but its tail, for the first day after birth, remains covered, and in consequence its movements are circular, and it spins round in spiral fashion. Soon, however, the tail straightens and it is able to swim right ahead, and is seen gamboling through the water, evidently in a state of enjoyment. Its sack of food, however, greatly interferes with its movements, and it is not till this is absorbed that it can swim swiftly. During this period the cod nurslings are kept

in the hatchery, and only when they are able to swim vigorously are they liberated in the outside waters to commence the battle of life.

A high temperature of the water will hasten the development of the embryo, and a low temperature will retard it; so that the process fromim pregnation to birth may vary from ten to forty days in duration, according to the condition of the water.

There is no more amazing and interesting sight than the growth of the embryo, day after day, as viewed with the microscope through its crystalline envelope. Every organ is seen shaping itself, as if by some mystic rhythm, till the heart begins to pulsate and propel the blood to all parts of the body and build up the frame from the tiny speck of protoplasm to the bulky, voracious ranger of the sea. We can view it as "it is made in secret and curiously wrought in the lowest parts of the earth," its "substance yet being imperfect." What profound mysteries too lie behind all that the microscope can reveal and all that the eye of science can penetrate! The secret of life is as impenetrable as ever. The mysterious power that directs the movements of those molecules which shape the living creature and determine its destiny, who can pretend to define or fathom! "In Thy book were all my members written, which day by day were fashioned when as yet there was none of them." "Fearfully and wonderfully made," is true of every living creature.

In many points the ova of the lobster presents a marked contrast to those of the cod-fish, and differ from them greatly in the mode of development. The cod ova, as we have seen, are impregnated in the water after they are extruded from the fish; the lobster ova are fecundated within the female before being extruded. The pairing of lobsters takes place after they have fully recovered from the process of shelling. During copulation the spermatozoa of the male are deposited, by its sexual organ, within the oviduct of the female, and there coming into contact with the ova fecundation is accomplished, and not till then are the eggs extruded. They are not, however, thrown into the water like the cod ova. They come from the oviduct covered with a glutinous substance which enables them to adhere to the swimmerets or fibrils underneath the tail. When in the act of spawning the lobster bends its tail forward, in order to catch the ova as they are extruded. The peculiar form of the tail, with its movable swimmerets, is admirably adapted to this purpose. This process of spawning is accomplished in the course of one day—furnishing another point of contrast to the codfish, which occupies several weeks in spawning.

The newly-spawned ova are of a uniform dark green colour, but become more and more transparent as the period of hatching approaches. They are carried by the lobster, attached to the swimmerets until they hatch, the motion keeping them clean and promoting their development. The period that is occupied from the extrusion of the egg till the hatching takes place is nine months. During all this time the ova are carried under the tail, and protected from foes by the rapid motion of the mother if attacked. The powerful tail of the lobster enables it to shoot backwards through the water with extraordinary rapidity. Mr. Nielsen, when investigating the habits of the lobster, was able, on one occasion, to measure the distance it could go by a single stroke of its tail, and found it to be 25 feet, in less than a second.

The non-transparent character of the lobster ova, for several months after being extruded, renders it difficult or impossible to study the embryo in the living egg, during its first stages of development. When the larvæ break from the egg, all the organs are

pretty well developed, with the exception of the claws, and can be distinguished through the transparent skin in which the body is enveloped. The young are not provided with any yolk-bag, but begin swimming about and feeding shortly after breaking from the egg. They are most voracious, and if kept in a confined place will devour each other, and fight till few remain alive. If, however, they are fed well, their cannibalistic, pugnacious tendencies are greatly lessened. In the hatchery they are fed on yolks of eggs, fresh fish liver, finely chopped meat of crabs and fish, and even flour. Their natural food, however, in this larval stage, is vegetable matter and minute animals found in aquatic plants.

When a week old, the young lobster has its first moult or casting of the skin, and a second when two weeks old. After another week it moults again and then the larval state is at an end. From this time its habits resemble more the grown lobster, and the large claws begin to develop and the shell to harden. After another week the lobster is completely developed. Another shelling process takes place, and the new shell becomes more and more like the colour of the natural lobster and increases in firmness. How often they shell after this period, during the first year, is not ascertained; neither is it known how often they shell during each year till they arrive at maturity; but as a 10 inch lobster is reckoned to be seven years old, they must in the first year shell more than once to reach that size.

The following figures show the number of ova which Mr. Nielsen counted on "berried" lobsters :—

| Size. | No. of Ova. | Size. | No. of Ova. |
|---|---|---|---|
| 10 inches | 18,000 | 13 inches | 24,105 |
| 11 " | 22,154 | 13½ " | 24,606 |
| 11½ " | 22,600 | 14 " | 25,000 |
| 12 " | 23,080 | 14½ " | 25,260 |
| 12¼ " | 23,264 | 15 " | 25,600 |
| 12½ " | 23,680 | | |

The eight inch lobsters are not "berried." The European nine inch lobster carries about 12,000 eggs. As a rule, in Newfoundland waters, lobsters are not mature under 10 inches.

In closing this paper the writer wishes to point out the desirability of establishing a Biological Station for the study of Ichthyology and Marine Biology in all their branches. This is a work for the Dominion of Canada whose fishing interests are so extensive, but, if established at some eligible locality on the shores of the Lower Provinces, such an institution would equally benefit the great fisheries of Newfoundland, and that colony might be expected to share in the expenses of its erection and working. The undertaking, however, should be national, and must be sustained from the funds of the State, as the whole community, directly or indirectly, would share in its benefits, and private liberality in new countries could not be expected to maintain an institution of this kind. The scientific and practical should be so combined as to render it a Fishery School. It would include a laboratory in which the structure and habits of all kinds of marine life would be studied, especially the life, conditions, food, mode of propagation, movements, etc., of such fishes as possess an economic value. Observations would be conducted, not only on the fauna, but also on the flora of the sea, so as to improve and enlarge our Zoological and Botanical sciences, and impart accurate information to the young who might desire to investigate such subjects. Embryology would form a prominent feature at such

a station. Practical instruction in the best modes of conducting fish-culture in all its branches would be given, and thus in such a school would be trained numbers of young men who would be qualified to take charge of hatcheries for the artificial propagation of both fresh and salt water fishes. At present the number of those who possess such qualifications is extremely limited, while the demand for their services is ever increasing. Classes of students from the Universities might profitably spend a few weeks each summer at such a Biological station, engaged in the study of marine life in particular, and in general, of the animal and vegetable resources of the sea. The national importance of such a training school will be evident at a glance.

The interests of pure biology, as a science, would be served by such an institution. The secrets of organic life are to be sought out best in the world of waters; and conflicting hypotheses regarding the origin and development of life are best proved or disproved by researches in sea areas. For modern investigations have shown that in variety of forms of life the sea is not less rich than the land. The fertility of the sea in fishes, crustacea, zoophytes, the lowest forms of sponge life, molluscs, etc., becomes more astonishing as researches are extended. In particular, the sea is the great magazine of invertebrate forms in which life is seen in its simplest shape, and here the student of invertebrate physiology must look for his materials. But all science, in the long run, will be found to have a practical bearing in some shape. And if we want to increase the quantities of our food fishes, our lobsters and oysters, all our operations must rest on a scientific foundation, and all our regulations of our fisheries must have their basis in a scientific study of fish-life. Failing such accurate knowledge, our legislation regarding the fisheries will be largely groping in the dark; and all efforts for their preservation and improvement will come short of the objects aimed at. A thorough knowledge of the mode of life, development, etc., of those fishes which constitute such a large portion of the national wealth of British North America, is essential to their preservation and the extension of these great industries.

Such a Biological station as is referred to need not in the beginning be on an extensive scale or very costly. When once commenced on a solid foundation, it would be sure to expand. In most civilized countries, laboratories for the study of marine fauna and flora are now established, and to these naturalists are resorting more and more as they find there ample materials for their studies and the best appliances. The finest establishment of the kind is that founded at Naples, some fifteen years ago, by a German biologist, Dr. Anthon Dohrn, which may now be regarded as an international institution, since it derives its support from all parts of the world, and is resorted by students of all nationalities. In the United States laboratories are established at Wood's Hall, near Gloucester, at Beaufort by the Johns Hopkins University, and at Newport by Agassiz. France boasts of four, and Austria has one at Trieste. In 1884, the Marine Biological Association of the United Kingdom was formed, and the result has been the erection of a magnificent laboratory at Plymouth from which great results may be anticipated. Many of the leading scientific men of England are deeply interested in this institution and lend it their support. Scotland too, since the establishment of its Fishery Board, has been doing excellent work in the scientific investigation of sea fishes. Such men as Dr. Wemyss Fulton, Professors McIntosh and Ewart, Mr. W. Anderson Smith, men of high scientific attainments, are doing admirable work in connection with the Fishery Board of Scotland, in prosecuting original

investigations among the sea fauna; while they bring their knowledge to bear practically on the great fishing industries of Scotland.

One other feature of such a Biological station as has been referred to is the aid it would render in the collection of specimens which could be distributed among the various museums of the Dominion, thus enriching their treasures and placing materials for the study of fish-life within the reach of all. At present the collection of such specimens, in the different museums, is reported to be very meagre and imperfect.

## APPENDIX.

The season for hatching at Dildo Hatchery, in 1892, closed August 1st. The total number of young codfish "planted" during the season by Mr. Nielsen was one hundred and sixty-five millions, being four times as many as in 1891, and nine times the output of 1890. This marked success has been partly owing to the construction of a salt water pond—an improvement introduced this year—in which the cod were allowed to spawn in the natural way, and the fertilized eggs were then syphoned into a proper receptacle, cleansed, measured, and placed in the hatching jars. The gain by this new method is 20 to 25 per cent in the number of ova hatched and a considerable saving of labour. The pond is 60 feet in length with an average breadth of 24 feet and a depth of 12 feet. It is capable of containing from 1,000 to 1,500 spawning codfish which would give an average hatching of four hundred millions in the season.

In this pond it was noticed that when in the act of spawning the cod come to the surface, and the male turns on its back, the two touching each other and their vents coming together. This is different from the view hitherto held by naturalists as to the mode of spawning.

When the water was 42° or over the ova were hatched in 14 days. A week after hatching the young had absorbed their yolk-sack and were ready for planting. The pond is supplied with fresh sea-water pumped from a depth of 30 feet by a small "Eclipse" windmill supplied by Fairbanks and Morse of Chicago.